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AN ECONOMIC ANALYSIS OF MULBERRY SILK PRODUCTION IN CHIKKABALLAPUR DISTRICT OF KARNATAKA

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ABSTRACT

The present study evaluates the costs and returns associated with mulberry silk production. Primary data were collected through personal interviews with 90 sericulture farmers from six randomly selected villages and 35 silk reelers from two *taluks*. The analysis reveals that the total establishment cost for mulberry cultivation amounts to ₹50,222.76 per acre, while the annual maintenance cost is ₹28,568.73 per acre. The overall cost of producing mulberry cocoons per batch is estimated at ₹44,234.86. Annually, the production cost of raw mulberry silk for six reeling basins totals ₹1,45,76,798.40. Gross returns from the sale of the main product and by-products of silk reeling amount to ₹1,60,46,945.76 per year, resulting in a net return of ₹14,70,147.36. This study highlights the profitability and economic viability of mulberry silk production, suggesting that while the initial and maintenance costs are significant, the industry remains profitable with a positive net return. The findings provide valuable insights for stakeholders in the sericulture sector, including farmers and policymakers, to make informed decisions regarding investment and management in silk production. Additionally, the study highlights the importance of efficient cost management and market strategies to enhance profitability in the mulberry silk industry.

Keywords: Cost and returns, Mulberry plantation, Cocoon production, Mulberry silk, Reeling

Sericulture is an agro-based industry renowned for producing silk, often celebrated as the world's most exquisite natural fiber. Known as "The Queen of Textiles," silk is distinguished by its luxury, durability, elegance, high absorbance, affinity for dyes, soft texture, and lightweight properties (Pawar *et al.*, 2012; Hosali & Murthy, 2015; Dyavappa *et al.*, 2016; Choudhari *et al.*, 2021; Architha & Murthy, 2021; Madhu *et al.*, 2023c). In 2020, global silk production reached 91,765 metric tons (MT), with China leading at 53,359 MT (58.14%), followed by India at 33,770 MT (36.80%). Other significant producers included Uzbekistan (2.21%), Vietnam (1.05%), Thailand (0.76%), and various other countries (1.04%) (International Sericulture Commission, 2020, http://www.inserco.org/en/).

India stands out globally for its ability to produce all four types of commercial silk: Mulberry, Tasar, Eri, and Muga, each with unique characteristics (Choudhari *et al.*, 2021; Madhu *et al.*, 2023b). The silk industry is a crucial sector in the Indian economy, offering high employment opportunities, requiring relatively low investment, and providing substantial returns. It plays a significant role in poverty alleviation and improving living standards by offering full-time employment to marginalized, small, and medium farmers in rural areas (Madhu *et al.*, 2023a; Madhu *et al.*, 2023c). Furthermore, the industry supports various local households, including landless farmers, by generating profits (Hosali & Murthy, 2015; Dyavappa *et al.*, 2016). Compared to agriculture, sericulture provides year-round work and higher remuneration for rural households (Yadav, 2008; Madhu *et al.*, 2023b). In the 2021-22 agricultural year, mulberry cultivation covered 2,42,277 hectares, yielding 1,87,241 tonnes of mulberry leaves. The production of raw silk in India totalled 34,903 MT, with contributions from Mulberry silk (25,818 MT or 73.97%), Eri silk (7,364 MT or 21.19%), Tasar silk (1,466 MT or 4.20%), and Muga silk (255 MT or 0.74%). The top five silk-producing states—Karnataka (11,292 MT), Andhra Pradesh (8,422 MT), Assam (5,462 MT), Jharkhand (2,185 MT), Tamil Nadu (1,834 MT), and Meghalaya (1,213 MT)—accounted for over 85% of the country's total mulberry silk production (Central Silk Board, 2021, https://csb.gov.in/).

Sericulture in Karnataka boasts a rich history extending over 235 years, dating back to its establishment in 1785 by Tippu Sultan, the Tiger of Mysore. In the 2019-20 period, Karnataka had a

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total area of 1,05,076 hectares dedicated to mulberry cultivation. Within the state, Chikkaballapur led with the largest area of 20,666 hectares (19%), followed by Kolar at 18.66%, Ramanagara at 18.05%, and Mandya at 15.66%. The total production of mulberry silk cocoons in Karnataka reached 79,008.81 metric tons. Mandya district was the largest producer, contributing 21,213.51 metric tons (26.84%), followed by Ramanagara with 19,492.61 metric tons (24.67%). Chikkaballapur ranked third, producing 12,269.41 metric tons (15.52%), while Kolar accounted for 12.73% of the state's production, among other contributors (Central Silk Board, 2020).

The production of mulberry silk involves a complex and labour-intensive process, beginning with the cultivation of mulberry plants, which serve as the primary food source for silkworms. Initial costs for mulberry cultivation encompass land preparation, planting, irrigation, fertilization, and pest management, among other factors (Madhu *et al.*, 2023a). These input costs can vary widely based on the scale of operations and the methods employed. Understanding these costs is essential for farmers to optimize their investments and enhance profitability. Once mulberry leaves are harvested, they are fed to silkworms, which spin cocoons that are subsequently harvested for silk production (Madhu *et al.*, 2023c). The costs associated with producing silk cocoons include expenses related to silkworm rearing, disease management, labour, and harvesting. Efficient management practices and the use of high-quality inputs can significantly impact both the yield and quality of the cocoons, thereby affecting overall returns. Additionally, the silk reeling process, which involves extracting silk threads from the cocoons, is capital-intensive and requires investment in reeling machinery and skilled labour. The efficiency of the reeling process and the quality of the silk produced directly influence the economic returns (Choudhari *et al.*, 2021; Madhu *et al.*, 2023b).

This study utilizes a comprehensive cost-benefit analysis to assess the profitability of each stage in the mulberry silk production process in Chikkaballapur. By identifying key cost drivers and potential areas for improvement, the research offers valuable insights for both farmers and policymakers. These insights aim to enhance the economic sustainability of the silk industry by optimizing resource allocation and ensuring the implementation of sustainable and economically viable sericulture practices in the region.

METHODOLOGY

Sampling method: The study was conducted in Chikkaballapur district, Karnataka, during 2021. Primary data were collected using a well-structured questionnaire, and a multistage purposive sampling technique was employed. Chikkaballapur was selected due to its significant role in mulberry cultivation within the state, making it an ideal location for examining the economic aspects of silk production. The district's prominence in mulberry silk production provides a rich source of data and insights, essential for understanding the economic dynamics of the industry. Within Chikkaballapur, the study focused on two *taluk*s: Sidlaghatta and Chintamani, chosen for their extensive mulberry plantations. From each *taluk*, three villages were selected. In each village, 15 mulberry-growing and cocoon-producing sericulture farmers were purposively chosen. These farmers were stratified based on two criteria: the area under mulberry cultivation and the number of Disease-Free Layings (DFLs) used for silkworm rearing. The area under mulberry was categorized into three groups: marginal farmers with less than 1 hectare, small farmers with 1-2 hectares, and medium farmers with more than 2 hectares (Raju & Sannappa, 2018). The stratification based on DFLs included: marginal farmers with fewer than 100 DFLs, small farmers with 100-200 DFLs, and medium farmers with more than 200 DFLs. This stratification ensured a diverse sample representing various scales of operation and practices. Additionally, 35 silk reelers using the cottage basin reeling technique were selected from the *taluks*. Including these reelers was crucial for capturing the full value chain of mulberry silk production, from cultivation through reeling, thus providing a comprehensive economic analysis.

Sample size: Total sample size of the study would be 125 respondents, which includes 90 sericulture farmers and 35 silk reelers. This sample size is justified by the need to balance breadth and depth in data collection. It ensures sufficient representation across different categories of farmers and reelers for analysis.

The research utilized structured interviews and questionnaires to gather information from marginal, small and medium farmers regarding various cost components. The questionnaire was meticulously designed to capture data on human labour, bullock and machine labour, cost of manure, mulberry cuttings/ plantings, fertilizers, and plant protection chemicals, as well as interest on working capital in mulberry establishment, maintenance and mulberry leaves yield. In case of cocoon production was collected information about number of DFLs used and cost of dfls, human labour, cost of disinfectants and marketing costs and also about depreciation cost on rearing equipment's, yield and returns from cocoon production. On other hand the costs incurred in silk reeling like establishment cost, raw cocoons cost, labour cost, firewood cost, yield and returns of silk. By documenting these specifics and categorizing costs across different farm sizes, the

study provided a comprehensive and reliable analysis of mulberry silk production.

Tabular analysis was utilized to examine the primary raw data collected from farmers concerning costs associated with mulberry garden establishment, mulberry maintenance, cocoon production, and silk reeling. The analysis included calculating returns from these activities using averages, percentages, and other relevant methods.

RESULTS AND DISCUSSION

Cost of mulberry establishment

Establishment costs refer to the expenses incurred during the initial year of mulberry crop establishment. Table 1 presents the inputs associated with mulberry crop establishment for marginal, small, and medium category farmers, as well as at the overall level. The establishment costs encompass various components, including the cost of mulberry cuttings or saplings, land preparation, ridge and furrow formation, farmyard manure (FYM) or other manures, fertilizers, plant protection chemicals, as well as human, machine, and bullock labour. As illustrated in Table 1 and Figure 1, the total establishment cost for mulberry was ₹50,222.76 per acre for all farmers. Within these costs, human labour constituted the largest share, amounting to ₹19,760.00 (39.34%), followed by the cost of cuttings at ₹10,475.27 (20.85%) and manure costs at ₹7,110.48 (14.15%). Establishment costs were notably higher for medium farmers, averaging ₹51,517.41, compared to small and marginal farmers, who incurred costs of ₹50,276.62 and ₹49,514.15, respectively. This increase is attributed to the more intensive use of inputs and the larger area under cultivation among medium farmers.

Table 1 reveals that among the establishment costs for marginal farmers, human labour had the highest share, amounting to Rs. 19,412.00 (39.20%), followed by the cost of saplings/cuttings at Rs. 10,331.25 (20.86%) and the cost of manures at Rs. 7,049.61 (14.23%), among other expenses. For small farmers, human labour also accounted for the largest proportion of establishment costs, totaling Rs. 19,644.00 (39.06%), with the cost of saplings at Rs. 10,419.44 (20.72%) and the cost of manures at Rs. 7,116.90 (14.15%). Similarly, in the case of medium farmers, human labour represented the largest share of establishment costs, valued at Rs. 20,124.00 (39.06%), followed by the cost of saplings at Rs. 10,628.98 (20.63%) and the cost of manures at Rs. 7,143.97 (13.87%). The data indicates a clear trend: as farm size increases, the total establishment cost also rises.

The overall analysis of mulberry garden establishment indicates that medium farmers incur higher establishment costs compared to marginal and small farmers. This trend reflects the greater financial capacity of medium farmers, who allocate more resources to human labour and manures/FYM in the establishment of their mulberry gardens. Similar findings of an increasing trend in establishment costs among marginal, small, and medium farmers have been reported by Susikaran (2020).

Maintenance cost of mulberry plantation

Cultivating high-quality mulberry leaves is crucial for successful silkworm rearing. To ensure a sustainable and productive mulberry plantation, it is essential to focus on effective maintenance practices. The cost of maintaining a mulberry plantation encompasses various inputs and services required to produce quality leaves in subsequent harvests, following the initial establishment of the plantation. Proper maintenance not only extends the economic life of the mulberry plantation but also enhances its overall productivity.

The profitability of any enterprise is determined by balancing costs and returns, which encompass both the expenses related to acquiring various resources and maintaining the mulberry crop. Typically, the costs associated with mulberry maintenance are categorized into two main types: operational costs and fixed costs. Operational costs include expenditures such as human labour for various tasks, bullock labour, machine power, manure, inorganic fertilizers, pesticides, and interest on variable costs. Fixed costs, on the other hand, consist of depreciation, land revenue, the rental value of owned land, apportioned establishment costs, and interest on fixed capital. Table 2 illustrates the various costs involved in mulberry production and details the distribution of operational and fixed costs per acre for different categories of farmers.

At the overall farm category level, the cost of mulberry maintenance amounted to ₹28,568.73 per acre (Table 2 and Figure 3). Of this total, variable costs represented ₹24,322.14, while fixed costs were

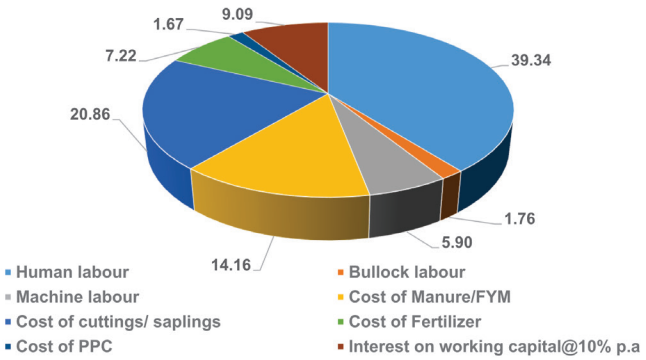

Fig. 1. Share of establishment cost for mulberry plantations among farmers

Table 1. Establishment cost (₹/acre) for mulberry plantation

Sr. No.	Particulars	Unit	Marginal farmers (<1ha)		Small farmers (1-2ha)		Medium farmers (>2ha)		Overall	
			Quantity	Total cost	Quantity	Total cost	Quantity	Total cost	Quantity	Total cost
1	Human labour	MD	48.53	19,412.00 (32.20)	49.11	19644.00 (39.06)	50.31	20,124.00 (39.06)	49.40	19760.00 (39.34)
	Women		25.28	10112.00 (20.42)	25.31	10124.00 (20.13)	25.68	10,272.00 (19.93)	25.38	10,152.00 (20.21)
	Men		23.25	9300.00 (18.78)	23.80	9520.00 (18.93)	24.63	9852.00 (19.12)	24.02	9,608.00 (19.13)
2	Bullock labour	BP	0.74	954.19 (1.92)	0.79	1008.14 (2.00)	0.80	1567.32 (3.04)	0.69	882.91 (1.75)
3	Machine labour	MH	3.98	2786.71 (5.62)	4.09	3003.30 (5.97)	4.18	3020.50 (5.86)	4.1	2962.57 (5.89)
4	Cost of Manure/FYM	Tonne	4.22	7049.61 (14.23)	4.27	7116.90 (14.15)	4.28	7143.97 (13.87)	4.26	7110.48 (14.15)
5	Cost of cuttings/ saplings	No's	4132.50	10,331.25 (20.86)	4167.77	10,419.44 (20.72)	4174.96	10628.98 (20.63)	4161.68	10,475.27 (20.85)
6	Cost of Fertilizer	Kg	163.03	3647.29 (7.36)	160.62	3594.06 (7.14)	162.96	3597.43 (6.98)	161.96	3625.28 (7.21)
7	Cost of PPC	Ltr	1.11	831.82 (1.67)	1.22	920.17 (1.83)	1.03	757.06 (1.47)	1.12	840.55 (1.67)
8	Interest on working capital @ 10% per annum	Rs		4501.28 (9.09)		4570.60 (9.09)		4678.15 (9.08)		4565.70 (9.09)
	Total			49,514.15 (100)		50,276.62 (100)		51,517.41 (100)		50,222.76 (100)

Note: Figures in the bracket indicate per centage values of the total.

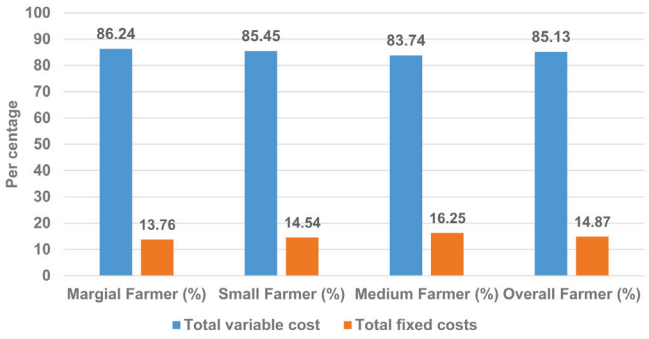

Fig. 2. Distribution of total costs for mulberry maintenance among farmers

₹4,246.59, accounting for 14.87% of the total costs. Within the variable costs, human labour constituted the largest expense, totaling ₹8,056.00 (28.19%), followed by manure at ₹6,627.38 (23.19%) and fertilizers at ₹4,090.65 (14.31%). Among the fixed costs, the rental value of land and depreciation were significant, amounting to ₹2,000.00 (7.00%) and ₹1,213.26 (4.24%), respectively.

The average per-acre cost of mulberry maintenance was observed to increase with the size of the mulberry area, with marginal farmers incurring an average cost of ₹27,056.18, small farmers ₹28,396.01, and medium farmers ₹30,111.10 (Fig. 2). This trend reflects a direct correlation between landholding size and maintenance costs. The increase in costs for larger landholdings is attributed to the more intensive use of human labour and inputs such as farmyard manure (FYM) and fertilizers, which are employed to ensure the production of high-quality mulberry leaves.

The data from the table further indicates that both total variable and fixed costs increased as farm size expanded from marginal to medium category farmers. For marginal farmers, the largest share of variable costs was attributed to human labour, amounting to ₹7,196.00 (26.58%), followed by farmyard manure (FYM) at ₹6,805.25 (25.15%) and fertilizers at ₹3,877.52 (14.33%). Among small farmers, human labour also represented the largest component of variable costs, totaling ₹8,100.00 (28.52%), with FYM at ₹6,586.34 (23.19%) and fertilizers at ₹4,096.52 (14.42%). For medium farmers, human labour continued to be the predominant variable cost, at ₹8,620.00 (28.62%), with FYM contributing ₹6,619.55 (21.98%) and fertilizers at ₹4,236.91 (14.07%). These figures illustrate the increasing investment in human labour and other inputs such as FYM and fertilizers as farm size grows.

Among the fixed costs for marginal farmers, the largest share was attributed to the rental value of owned land, amounting to ₹2,000.00 (7.39%), followed by depreciation costs of ₹752.75 (2.78%). For small farmers, the rental value of owned land remained the most significant fixed cost at ₹2,000.00 (7.40%), with depreciation accounting for ₹1,108.54 (3.90%). In the case of medium farmers, the rental value of owned land continued to be the predominant fixed cost at ₹2,000.00 (6.64%), followed by depreciation costs of ₹1,778.48 (5.90%). These findings are consistent with those reported by Hosali and Murthy (2015), Raju and Sannappa (2018), and Susikaran (2020).

The analysis of the total cost of mulberry maintenance reveals that medium farmers incur the highest total costs compared to marginal and small farmers. Among the variable costs, human labour consistently represents the largest expense due to its essential role in sericulture activities such as mulberry harvesting, weeding, and chapping—tasks that cannot be easily replaced by machine or bullock labour. Following human labour, machine labour, bullock labour, and fertilizers constitute the remaining variable costs. Regarding fixed costs, the rental value of land is the most significant, followed by depreciation costs and interest on fixed capital. This pattern is attributed to the more intensive use of human labour and fertilizers by medium farmers compared to other farm categories. These findings align with the observations reported by Swamy Naika (2017).

Yield and returns from mulberry production

In the present study, mulberry leaves are the primary product, with mulberry stalks serving as a by-product. As detailed in Table 3, the overall yield of mulberry leaves was 5,806.01 kg, generating gross returns of ₹32,211.48 and net returns of ₹3,642.75. The highest gross and net returns were achieved by medium farmers, with gross returns of ₹33,884.92 and net returns of ₹3,773.82. Small farmers followed with gross returns of ₹31,722.37 and net returns of ₹3,326.36, while marginal farmers had the lowest gross returns of ₹30,095.81 and net returns of ₹3,039.63. The total quantity of mulberry leaves produced by marginal, small, and medium farmers was 5,422.26 kg, 5,717.30 kg, and 6,109.70 kg, respectively.

An increasing trend in yield was observed as the size of the mulberry garden expanded. This trend can be attributed to the higher maintenance costs incurred by medium farmers, who also utilized a greater proportion of inputs. These findings are consistent with the results reported by Susikaran (2020).

Cost of the mulberry silk cocoon

The costs and returns from mulberry silk cocoon production were assessed based on the Disease Free Layings (DFLs) per batch. Given that mulberry silkworm rearing is a highly labour-intensive process, effective cocoon production is crucial for achieving better prices

Table 2. Cost associated with mulberry maintenance (₹/acre/crop)

Sr. No.	Particulars	Unit	Marginal farmers (<1 ha)	%	Small farmers (< 1-2 ha)	%	Medium farmers (> 2ha)	%	Overall	%
A	Operational or Variable costs									
1	Human labour cost	₹	7196.00	26.58	8100.00	28.52	8620.00	28.62	8056.00	28.19
	Women	₹	4272.00	15.78	4568.00	16.08	4840.00	16.07	4592.00	16.07
	Men	₹	2924.00	10.80	3532.00	12.43	3780.00	12.55	3464.00	12.12
2	Bullock labour	₹	955.71	3.53	1025.74	3.61	1100.13	3.65	1028.97	3.60
3	Machine labour	₹	1504.93	5.56	1541.96	5.43	1617.23	5.37	1557.77	5.45
4	Manure/FYM cost (Tonnes)	₹	6805.25	25.15	6586.34	23.19	6619.55	21.98	6627.38	23.19
5	Fertilizer cost	₹	3877.52	14.33	4096.52	14.42	4236.91	14.07	4090.65	14.31
6	Plant protection chemical cost	₹	872.47	3.22	708.97	2.49	731.48	2.42	750.27	2.62
7	Interest on working capital @ 10%	₹	2121.18	7.83	2205.95	7.76	2292.53	7.61	2211.04	7.73
	Total variable cost	₹	23,333.06	86.24	24,265.48	85.45	25,217.83	83.74	24,322.14	85.13
B	Fixed costs									
1	Land revenue	₹	80.26	0.29	80.62	0.28	80.01	0.26	80.10	0.28
2	Depreciation	₹	752.75	2.78	1108.54	3.90	1778.48	5.90	1213.26	4.24
3	Rental value of owned land	₹	2000.00	7.39	2000.00	7.40	2000.00	6.64	2000.00	7.00
4	Interest on fixed capital @ 12%	₹	339.96	1.25	382.69	1.34	463.01	1.53	395.20	1.38
5	Apportioned establishment cost	₹	550.15	2.03	558.68	1.96	571.77	1.89	558.03	1.95
	Total fixed costs	₹	3723.12	13.76	4130.53	14.54	4893.27	16.25	4246.59	14.87
	Total costs	₹	27,056.18	100	28,396.01	100	30,111.10	100	28,568.73	100

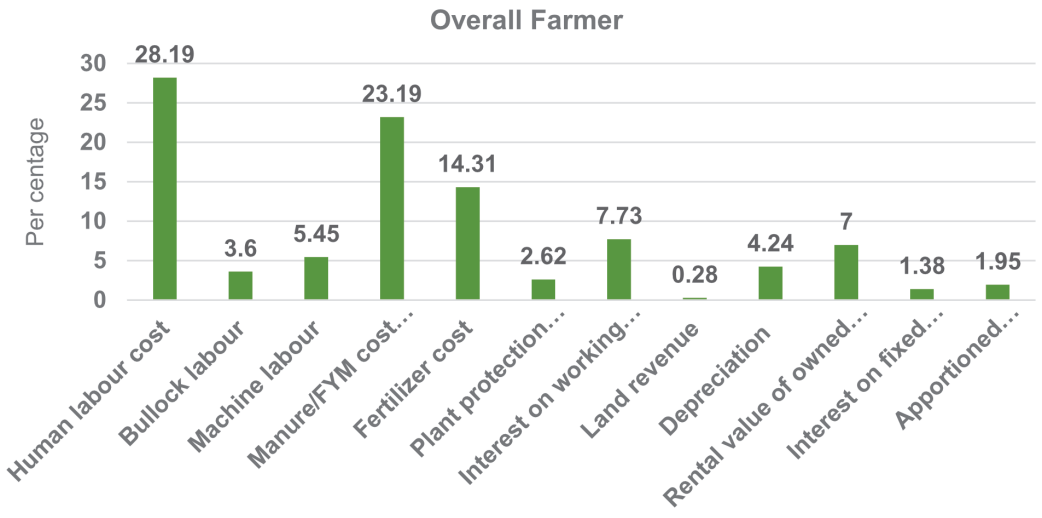

Fig. 3. Breakdown of total cost components for mulberry maintenance among all farmers

Table 3. Yield and financial returns (₹/acre/crop) from mulberry production

Sr. No.	Particulars	Marginal farmers		Small farmers		Medium farmers		Overall	
		Quantity	Value	Quantity	Value	Quantity	Value	Quantity	Value
1	Main product								
	Mulberry leaves (Kg)	5422.26	29822.42 (99.09)	5717.30	31445.16 (99.13)	6109.70	33,603.32 (99.16)	5806.01	31,933.09 (99.13)
2	By-product Mulberry stalks (Q)	0.91	273.39 (0.90)	0.92	277.21 (0.87)	0.93	281.60 (0.84)	0.92	278.33 (0.86)
	Gross returns	30,095.81 (100)		31,722.37 (100)		33,884.92 (100)		32,211.48 (100)	
	Net returns	3039.63		3326.36		3773.82		3642.75	

Note: Figures in the brackets indicate the percentage values to the total.
Kg: kilogram(s), Q: Quintal

for the output. Mulberry silk cocoon production is a critical component of the sericulture enterprise. The analysis of the costs associated with this production is categorized into two main areas: operational costs and fixed costs, as detailed in Table 4.

At the overall level, the total cost of mulberry silk cocoon production for farmers was ₹44,234.86 per batch. Of this total, operational costs constituted ₹43,261.72 (97.81%), while fixed costs amounted to ₹973.14 (2.19%). Within the operational costs, the cost of mulberry leaves was the largest component, accounting for ₹17,986.11 (40.66%). This was followed by human labour, which contributed ₹12,388.00 (28.00%), and the cost of Disease Free Layings (DFLs) or *chawki* worms, which was ₹4,666.66 (10.54%) (Fig. 5).

The average per-batch rearing cost for mulberry silkworms, or cocoon production, was found to increase with the number of Disease Free Layings (DFLs). For marginal farmers, the cost was ₹27,352.31; for small farmers, it was ₹48,987.76; and for medium farmers, it was ₹73,146.07. This trend indicates a direct relationship between the number of DFLs used in silkworm rearing and the associated costs (Fig. 4).

It was further observed that both total variable and fixed costs exhibited an increasing trend with farm size, rising from marginal to medium farmers. For marginal farmers, the operational costs amounted to ₹26,484.96 (96.82%). Within these operational costs, the cost of mulberry leaves was the largest component, totaling ₹10,914.63 (39.90%), followed by human labour, which accounted for ₹7,536.00 (27.55 %), and the cost of Disease Free Layings (DFLs) or *chawki* worms amounted to ₹2,817.07 (10.29%), among other expenses.

Among small farmers, the operational cost amounted to ₹47,926.05 (97.83%). Within these operational costs, the cost of mulberry leaves was ₹20,333.33 (41.50%), followed by human labour at ₹13,220.00 (26.98%), and the cost of Disease Free Layings (DFLs) or *chawki* worms at ₹5,272.72 (10.76%). For medium farmers, the operational cost was ₹71,935.83 (98.34%). Here, the cost of mulberry leaves accounted for ₹31,265.62 (42.74%), followed by human labour at ₹19,816.00 (27.09%), and the cost of DFLs or *chawki* worms at ₹8,156.25 (11.15%).

Among the fixed costs for marginal farmers, the total fixed cost amounted to ₹867.36 (3.17%), with the largest portion attributable to depreciation on rearing buildings and assets, accounting for ₹774.43 (2.83%). For small farmers, the total fixed cost was ₹1,061.00 (2.16%), with depreciation on rearing buildings and assets again representing the major share, totaling ₹947.96 (1.93%). A similar pattern was observed for medium farmers, where depreciation on rearing buildings and assets continued to be the predominant fixed cost. These findings are consistent with the results reported by Hosali and Murthy (2015).

Based on the results, it can be inferred that the total cost of silk cocoon production per batch is highest for medium farmers, followed by small and marginal farmers. This increase in costs for medium farmers is attributed to the higher number of Disease Free Layings (DFLs) or *chawki* worms reared, as well as increased expenditures on mulberry leaves, labour, and DFLs or *chawki* worms.

Returns from Mulberry Silk Cocoon Production

Table 5 presents the returns from mulberry silk cocoon production per batch. The yields are categorized into main products and by-products. The main products include high-quality and low-quality cocoons, while the by-products consist of litter and crop waste, which are used as animal feed.

At the overall category level, the main product contributed significantly to the gross returns, totaling ₹50,043.67 (89.85%), while by-products generated ₹5,659.59 (10.15%). This resulted in net returns of

Table 4. Cost of mulberry silk cocoon production (₹/batch)

Sr. No.	Operations	Marginal farmers (<100 DFLs)	%	Small farmers (100-200 DFLs)	%	Medium farmers (> 200 DFLs)	%	Overall	%
A	Operational or Variable costs								
1	Cost of DFLs/ *Chawki* worm (including transportation cost)	2817.07	10.29	5272.72	10.76	8156.25	11.15	4666.66	10.54
2	Human labour	7536.00	27.55	13220.00	26.98	19,816.00	27.09	12,388.00	28.00
	Women	4580.00	16.74	7860.00	16.04	11,816.00	16.15	7436.00	16.81
	Men	2956.00	10.80	5360.00	10.94	7724.00	10.55	4952.00	11.19
3	Cost of disinfectants	276.71	1.01	356.05	0.72	665.77	0.91	408.87	0.92
	Bed disinfectant	144.51	0.52	215.15	0.43	329.68	0.45	203.33	0.45
	Lime powder	83.90	0.30	140.00	0.28	208.75	0.28	126.66	0.28
	Uzi powder	50.30	0.18	90.90	0.18	127.34	0.17	78.88	0.17
4	Cost of *uzi* trap	110.97	0.40	158.18	0.32	236.25	0.32	150.55	0.33
5	Mulberry leaf cost	10,914.63	39.90	20,333.33	41.50	31,265.62	42.74	17,986.11	40.66
6	Hiring of mountages	1066.09	3.89	1968.18	4.01	2857.5	3.90	1715.33	3.87
7	Cost of paraffin paper	271.87	0.99	492.12	1.00	781.62	1.06	444.62	1.00
8	Cost of newspaper	193.29	0.70	321.97	0.65	484.37	0.66	292.22	0.66
9	Marketing cost	827.69	3.02	1327.05	2.70	1783.76	2.43	1180.76	2.66
10	Electricity cost	62.92	0.23	119.54	0.24	130.62	0.17	95.72	0.21
11	Interest on working capital @10%	2407.72	8.80	4356.91	8.89	6539.62	8.94	3932.88	8.89
	Total variable cost	26,484.96	96.82	47,926.05	97.83	71935.83	98.34	43,261.72	97.81
B	Fixed costs								
1	Depreciation on rearing building & assets	774.43	2.83	947.96	1.93	1080.58	1.47	868.88	1.96
2	Interest on fixed capital @ 12%	92.93	0.33	113.75	0.23	129.66	0.17	104.26	0.23
	Total fixed costs	867.36	3.17	1061.71	2.16	1210.24	1.65	973.14	2.19
	Total cost	27,352.31	100	48,987.76	100	73,146.07	100	44,234.86	100

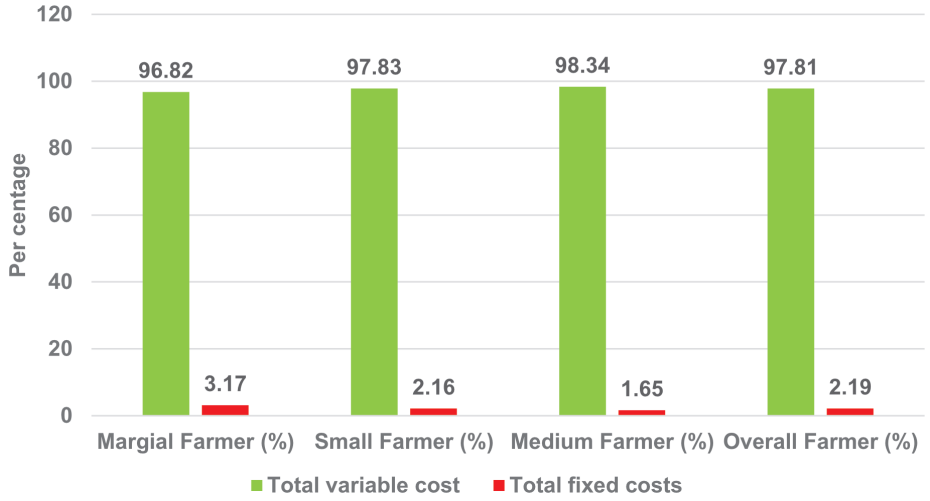

Fig. 4. Distribution of total costs among farmers in mulberry silk cocoon production

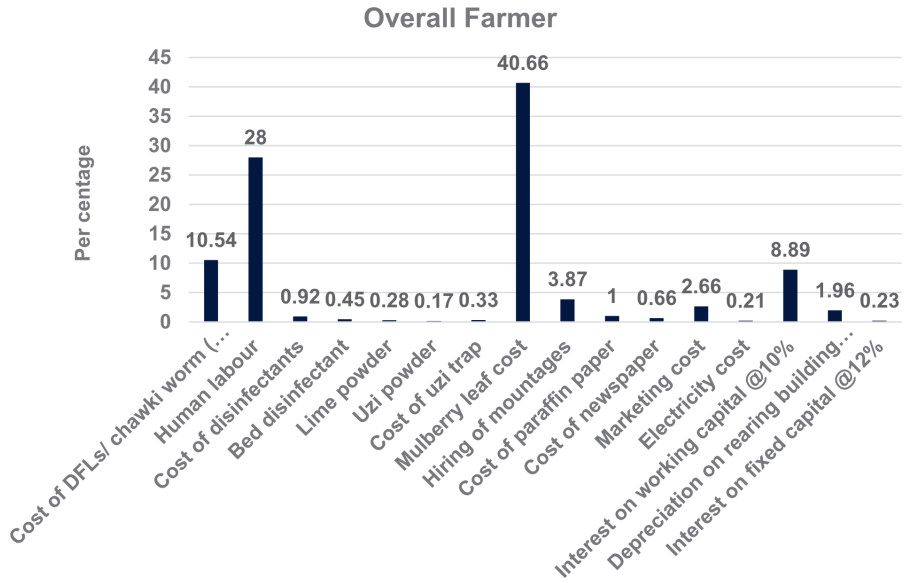

Fig. 5. Breakdown of total cost components in mulberry silk cocoon production across all farmers

₹10,659.46 (Table 5). Gross returns were highest for medium farmers, amounting to ₹95,715.62, followed by small farmers at ₹63,240.09, and marginal farmers at ₹34,002.73. Similarly, net returns were highest for medium farmers, reaching ₹21,992.81, followed by small farmers at ₹14,150.00, and marginal farmers at ₹6,619.63.

For the overall category, the main product obtained was 124.57 kg of cocoons, comprising 118.13 kg of good-quality cocoons and 6.44 kg of low-quality cocoons. By-products included 2.40 tonnes of litter and 8.79 quintals of fodder. For marginal farmers, the main product yielded 76.21 kg of cocoons, with 72.17 kg classified as good quality and 4.04 kg as low quality. By-products comprised 1.40 tonnes of litter and 6.62 quintals of fodder. Small farmers produced a total of 140.61 kg of cocoons, including 133.40 kg of good-quality cocoons and 7.21 kg of low-quality cocoons. Their by-products included 2.75 tonnes of litter and 10.16 quintals of fodder. Medium farmers achieved a main product yield of 215.37 kg of cocoons, with 204.37 kg being good quality and 11.00 kg low quality. The by-products were 4.29 tonnes of litter and 14.09 quintals of fodder.

An increasing trend in returns was observed with the size of the farms. Gross and net returns were notably higher for medium farmers compared to small and marginal farmers. This can be attributed to the greater number of Disease Free Layings (DFLs) used for silkworm rearing by medium-sized farms, which contributed to their higher returns.

Table 5. Returns from mulberry silk cocoon production per rearing batch (₹/batch)

A	Main product	Marginal farmers (< 100 DFLs)		Small farmers (100 -200 DFLs)		Medium farmers (> 200 DFLs)		Overall	
		Quantity	Value (Rs)	Quantity	Value (Rs)	Quantity	Value (Rs)	Quantity	Value (Rs)
1	High quality cocoon (Kg)	72.17	30,090.90 (88.49)	133.40	55,796.40 (88.22)	204.37	84,100 (87.86)	118.13	49,117.83 (88.19)
2	Low quality cocoon (Kg)	4.04	567.22 (1.66)	7.21	1047.27 (1.65)	11.00	1543.75 (1.61)	6.44	916.84 (1.64)
	Total A	76.21	30,658.12 (90.16)	140.61	56,843.67 (89.88)	215.37	85,643.75 (89.47)	124.57	50,043.67 (89.85)
B	By-products								
1	Litter (tonnes)	1.40	2360.38 (6.94)	2.75	4617.28 (7.30)	4.29	7605.46 (7.94)	2.40	4120.37 (7.39)
2	Fodder (Q)	6.62	984.26 (2.89)	10.16	1779.17 (2.81)	14.09	2466.41 (2.57)	8.79	1539.22 (2.76)
	Total B		3344.64 (9.84)		6396.45 (10.11)		10,071.87 (10.52)		5659.59 (10.16)
	Gross returns		34,002.73 (100)		63,240.09 (100)		95,715.62 (100)		55,694.28 (100)
	Net returns		6619.63		14,150.00		21,992.81		10,659.46

Note: Figures in the brackets indicate the percentage values of the total.

Cost and returns from mulberry raw silk production

Capital requirements for establishing a silk reeling unit

The capital investment required for establishing a cottage basin reeling unit is presented in Table 6 and Fig. 6. For an average of six reeling basins, the total capital investment amounted to ₹7,13,693.93. The largest portion of this investment was allocated to the construction of the reeling building, which cost ₹5,03,531.90 (70.55%). This was followed by the cost of the reeling basins, totaling ₹1,78,576.80 (25.02%). Additional costs included ₹8,421.54 (1.17%) for motors with 0.5 HP capacity, ₹12,317.52 (1.72%) for the water storage tank, ₹4,003.10 (0.56%) for electricity and water connection charges, and ₹6,843.07 (0.95%) for miscellaneous expenses.

Table 6. Capital requirements for establishing a cottage basin reeling unit (Unit: 6 basins)

Sr. No.	Item	Number	Cost per unit (₹)	Life span	Total cost (₹)
1	Cost of building	-	503,531.90	50	5,03,531.90 (70.55)
2	Cost of reeling basins	6	29762.80	25	1,78,576.80 (25.02)
3	Cost of motor (0.5 HP)	2	4210.77	15	8421.54 (1.17)
4	Cost of water storage tank	3	4105.84	10	12,317.52 (1.72)
5	Cost of electrical and water connection	-	4003.10	-	4003.10 (0.56)
6	Miscellaneous	-	6843.07	-	6843.07 (0.95)
	Total				7,13,693.93 (100)

Note: Figures in the brackets indicate the percentage values of the total.

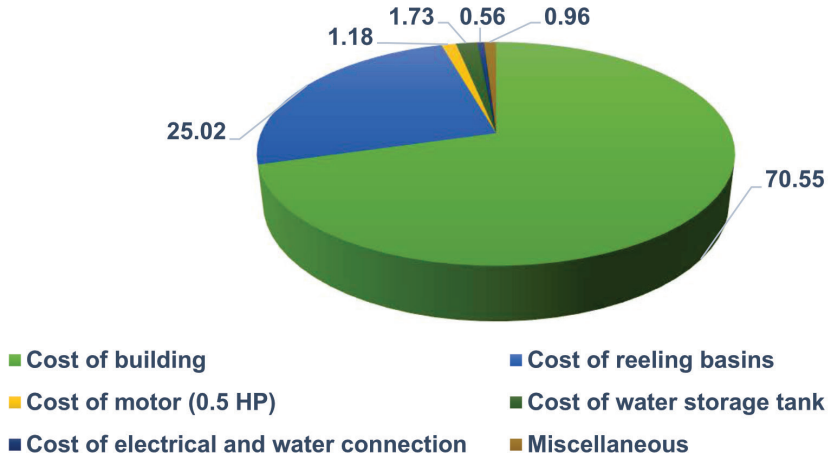

Fig. 6. Breakdown of cost components in the establishment of a cottage basin silk reeling unit

Average annual cost for production of mulberry raw silk

The cottage basin has been developed to enhance the quality of raw silk reeled and address the shortcomings in silk quality associated with the *Charaka* method of reeling. In the study area, most silk reelers utilize cottage basins for reeling silk from cocoons. The total cost of raw silk production, as assessed for six reeling basins annually, is divided into variable and fixed costs.

It is evident from table 7 and figure 7 that the total cost of mulberry raw silk production for six basins annually was ₹1,45,76,798.40. Of this, the major portion was operational costs, totaling ₹1,45,54,845.60 (99.85%), while fixed costs amounted to ₹21,952.82 (0.15%). Among the variable costs, the highest expense was for mulberry cocoons, at ₹1,26,36,120.19 (86.68%), followed by human labour at ₹3,68,607.65 (2.52%). For fixed costs, depreciation was the largest component, amounting to ₹16,820.60 (0.11%), with repair and maintenance costs at ₹2,289.93 (0.01%). These findings align with results reported by Mahesh (2012), Manjunatha (2017), and Shaik (2017).

It is also evident from the table 7 that the total cost of mulberry raw silk production per basin annually is ₹24,29,466.40. Of this, the majority of the cost is attributed to variable expenses, amounting to ₹24,25,807.60 (99.85%), with fixed costs totaling ₹3,658.80 (0.15%). Within the variable costs, the cost of mulberry cocoons is the largest at ₹21,06,020.03 (86.68%), followed by human labour at ₹61,434.60 (2.52%). The cost of firewood or fuel is estimated at ₹24,547.97 (1.01%), among other expenses.

Among the fixed costs, the largest share was attributed to depreciation, amounting to ₹2,803.43 (0.11%), while repair and maintenance costs were ₹381.65 (0.01%). These findings are consistent with those reported by Mahesh (2012) and Manjunatha (2017).

Average annual returns from mulberry raw silk production

Table 8 and Figure 8 illustrate the returns from mulberry raw silk production for six basins. The yields and returns are categorized into main products and by-products. The main product is mulberry raw silk, while the by-products include silk waste or jute, dead pupae, and defective cocoons. It is evident from the table that the gross returns from mulberry raw silk production per six basins amount to ₹1,60,46,945.76 annually.

The main contributor to gross returns was mulberry raw silk, valued at ₹1,55,86,671.60 (97.13%). By-products contributed less significantly, with silk waste accounting for ₹2,75,519.24 (1.71%), dead pupae valued at ₹1,14,109.80 (0.71%), and defective cocoons at ₹70,645.18 (0.44%). The net returns totaled ₹14,70,147.36.

Table 8 illustrates the average yield from cottage basin reeling. The main product, mulberry raw silk, was estimated to be 4,561.80 kg, while the by-products—silk waste or jute, dead pupae, and defective cocoons—totaled 458.20 kg, 13,252.00 kg, respectively. Additionally, the average yield per unit was 760.30 kg of mulberry raw silk, with by-products yielding 76.36 kg of silk waste or jute, 2,208.67 kg of dead pupae, and 71.91 kg of defective cocoons per year.

From the table, it is evident that the benefit-to-cost (B: C) ratio was 1.10, and the renditta was 7.80 kg. These findings are consistent with those reported by Mahesh (2012), Manjunatha (2017), and Shaik (2017), who observed similar results.

Table 7. Average annual cost of mulberry raw silk production

Sr. No.	Item	Unit	Physical quantity		Cost (₹)	
			6 units	Per unit	6 units	Per unit
A	**Operational or Variable cost**					
1	Cocoon	Kg	35,176.38	5862.73	1,26,36,120.19 (86.68)	21,06,020.03 (86.68)
2	Labours	MD	1872.94	312.15	3,68,607.65 (2.52)	61,434.60 (2.52)
	Women		1167.75	194.62	2,22,964.65 (1.52)	37,160.77 (1.52)
	Men		705.19	117.53	145,643.00 (0.99)	24,273.83 (0.99)
3	Firewood/fuel (tonnes)		84.16	14.02	1,47,287.82 (1.01)	24547.97 (1.01)
4	Water (4000 Litres capacity tankers)		154.94	25.82	77,474.96 (0.53)	12,912.49 (0.53)
5	Miscellaneous expenses	₹			2187.14 (0.01)	364.52 (0.01)
6	Interest on working capital @ 10%	₹			13,23,167.78 (9.07)	22,05,27.96 (9.07)
	Total variable cost	₹			1,45,54,845.60 (99.85)	24,25,807.60 (99.85)
B	Fixed costs					
1	Licence fee per year	₹			490.24 (0.003)	81.70 (0.003)
2	Depreciation	₹			16,820.6 (0.11)	2803.43 (0.11)
3	Repair and maintenance	₹			2289.93 (0.01)	381.65 (0.01)
4	Interest on fixed capital @ 12%	₹			2352.09 (0.01)	392.01 (0.01)
	Total fixed cost	₹			21,952.82 (0.15)	3658.80 (0.15)
	Total cost (A+B)	₹			1,45,76,798.40 (100)	24,29,466.40 (100)

Note: Figures in the brackets indicate the percentage values of the total.
MD: Mandays

Factors influencing the mulberry silk returns

The profitability of mulberry silk production is influenced by several critical factors, beginning with the yield and quality of mulberry leaves. As the primary food source for silkworms, the quality of these leaves directly affects cocoon production (Dyavappa *et al.* 2016). Key determinants of leaf quality and yield include soil fertility, climatic conditions, and irrigation practices. Effective pest and disease management, along with the use of high-yielding mulberry varieties, further enhances leaf production. Silkworm health and management are also pivotal, as optimal conditions and the use of improved breeds can significantly enhance cocoon quality and overall profitability. Additionally, modern technology in reeling processes improves both the quality and yield of raw silk. Stable market prices are crucial for ensuring the economic viability and sustainability of mulberry silk production. Collectively, these factors contribute to the success and sustainability of the silk industry.

Compared to other agricultural activities, mulberry plantation and cocoon production typically require lower initial investments. In contrast, silk reeling demands a higher upfront investment; however, it yields substantial returns due to the high market value of silk. Silk reeling also provides consistent year-round employment, significantly benefiting rural livelihoods and contributing to economic stability across sericulture activities. The labour-intensive nature of silk farming creates ongoing

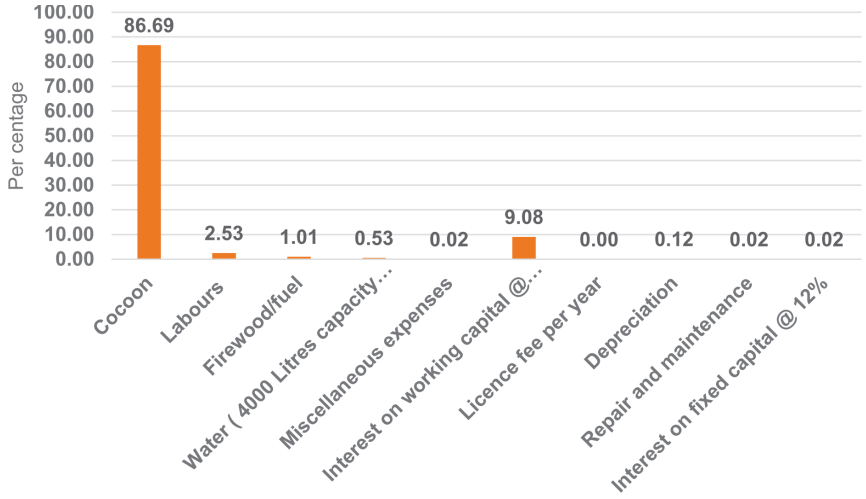

Fig. 7. Breakdown of average annual costs in mulberry raw silk production

employment opportunities, which is particularly advantageous for women in rural areas (Kumar, 2018).

Cereal crops like rice and wheat require lower initial investments but provide lower returns per unit area, and they are subject to market price fluctuations and seasonal demand, resulting in less stable employment. Horticultural crops, such as fruits and vegetables, can offer higher profits due to premium market prices and multiple harvests per year, but they demand significant investments in inputs like irrigation and pest control and are prone to spoilage risks (Kumar, 2018). In comparison, mulberry silk farming, while requiring higher initial investments and ongoing care similar to horticultural crops, proves more profitable and stable in terms of income and employment. Sericulture, being a vibrant, labor-intensive sector, enhances rural economies through sustained income streams and employment opportunities. India's leadership in producing all commercial silks, particularly mulberry silk, highlights its potential for income generation and employment. Continued improvements in production efficiency and market diversification are expected to further improve the profitability and sustainability of the silk industry (Tiwari, 2020; Kumara and Gayathri, 2014; Vinay, 2023).

Integrating sericulture into agricultural strategies can substantially boost rural household incomes and employment, providing a viable alternative to traditional agricultural activities. The sector's inclusive employment practices, which engage both male and female labour, further highlight its socio-economic importance (Madhu *et al.*, 2023a; Vinay, 2023). As ongoing efforts focus on optimizing production techniques and expanding market opportunities, sericulture is well-positioned to play an increasingly critical role in agricultural diversification and economic growth.

Table 8. Annual returns from mulberry raw silk production

Sr. No.	Particular	Physical quantity		Costs (₹)		
		6 Units	Per unit	6 Units	Per unit	%
A	Main product					
1	Raw silk production (Kg)	4561.80	760.30	1,55,86,671.60	25,97,778.60	97.13
B	By-products					
2	Silk waste (Kg)	458.20	76.36	2,75,519.24	45,785.07	1.71
3	Dead pupae (Kg)	13252.00	2208.67	1,14,109.80	19,018.29	0.71
4	Defective cocoon (Kg)	431.45	71.91	70,645.18	11,774.20	0.44
	Gross returns			1,60,46,945.76	26,74,490.95	100
	Net returns			14,70,147.36	2,45,024.56	
	B: C ratio			1.10	1.10	
	Renditta (Kg)	7.80	7.80			

Note: Figures in the brackets indicate the percentage values of the total.

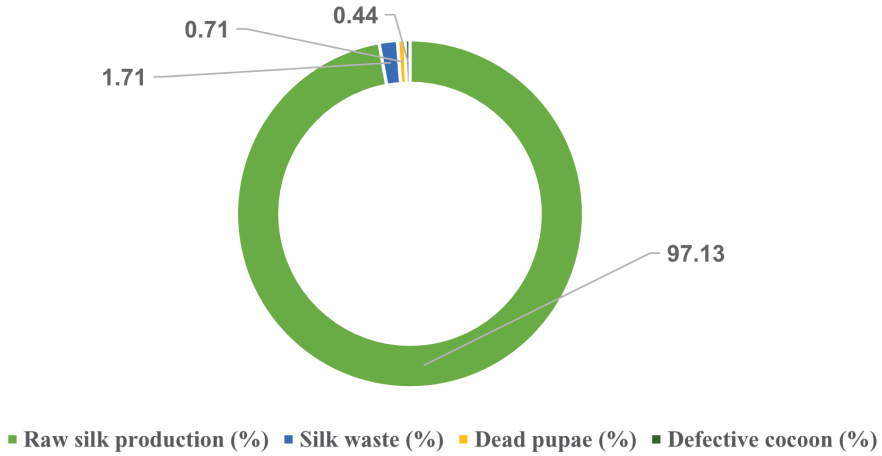

Fig. 8. Distribution of returns from mulberry raw silk production

CONCLUSION

The analysis of mulberry cultivation and silk cocoon production highlights key insights into the cost and returns associated with different farm sizes—marginal, small, and medium. Medium farmers incur the highest establishment and maintenance costs, but also achieve greater gross and net returns as farm size increases. The per-batch cost of mulberry silkworm rearing rises with the number of Disease Free Layings (DFLs), showing a direct correlation. The returns from mulberry raw silk production yield a B:C ratio of 1.10 and a renditta of 7.80 Kg, indicating that 7.80 Kg of cocoons are needed to produce 1 Kg of raw silk. To support farmers, targeted subsidies should be introduced to ease establishment and maintenance costs, and financial institutions should offer lower interest rates for productivity-enhancing inputs. Additionally, capacity-building programs are recommended to improve small and marginal farmers' skills in mulberry cultivation and cocoon production, covering areas such as integrated pest management, sustainable practices, and post-harvest techniques.

Authors' contribution

Conceptualization of research work and designing of experiments (DMD, DKS, TK);

Execution of field/ lab experiments and data collection (DMD); Analysis of data and interpretation (DMD, DKS, HG, HS, TK); Preparation of manuscript (DMD, DKS)

Conflicts of interest

The authors declare that they have no conflict of interest.

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